COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

CANADA • UNITED STATES

CANADIAN SECTION
G.M. MacNABB, Chairman
J. Allen, Member

UNITED STATES SECTION
H.H. KENNON, Chairman
R.H. Wilkerson, Member

31 December 1990

The Honorable James Baker
The Secretary of State
Washington, DC

The Honourable Jake Epp
Minister of Energy, Mines and Resources
Ottawa, Ontario

Gentlemen:

Reference is made to the Treaty between the United States of America and Canada, relating to co-operative development of the water resources of the Columbia River basin, signed at Washington, DC, on 17 January 1961.

In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the twenty-sixth Annual Report, dated 30 September 1990, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1989 to 30 September 1990.

Respectfully submitted:

For the United States

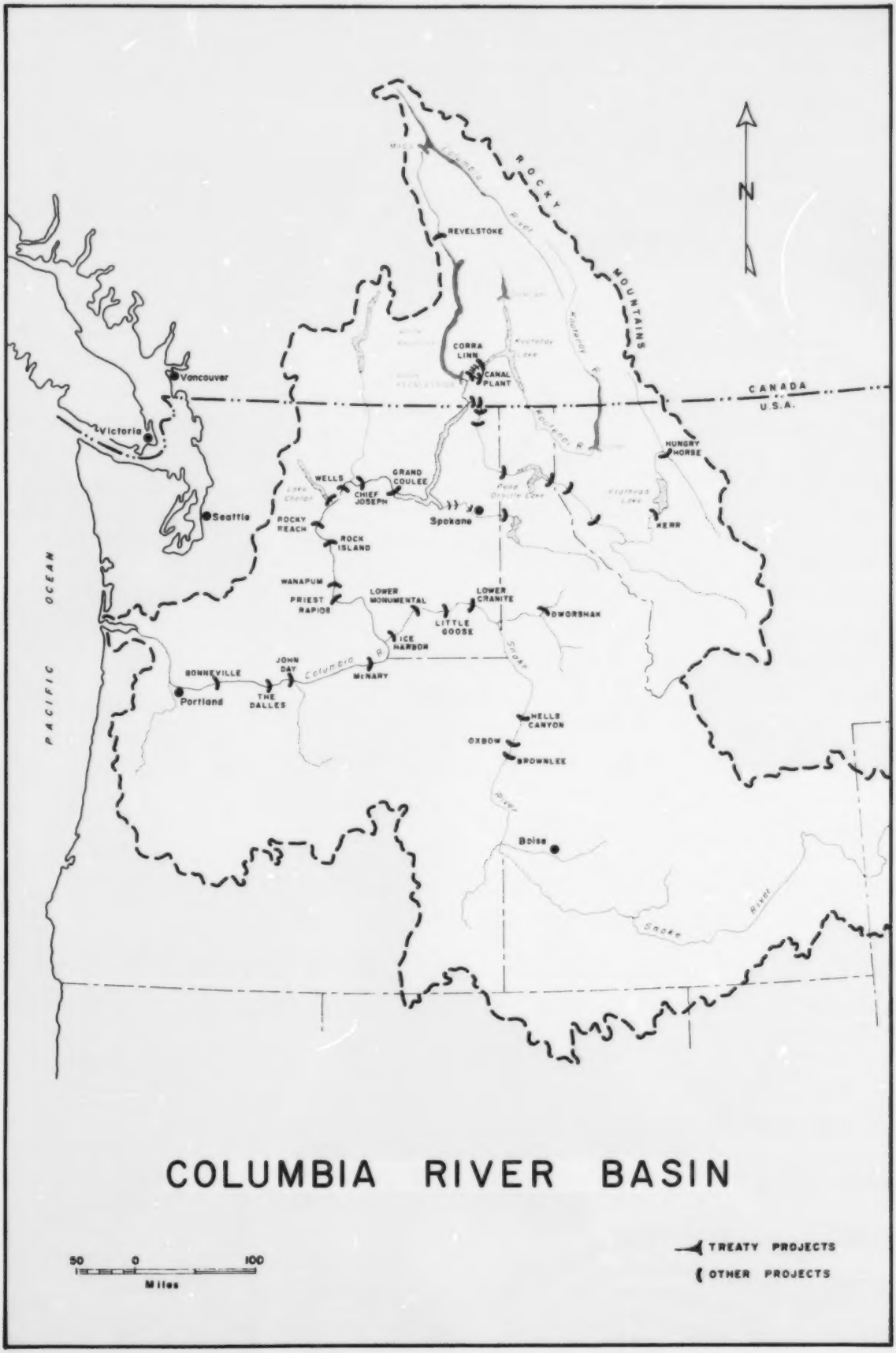
Herbert H. Kennon, Chairman

Ronald H. Wilkerson

For Canada

G. M. MacNabb, Chairman

J. Allan



COLUMBIA RIVER BASIN

ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C. **Ottawa, Ontario**

30 September 1990

92-02164/

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Photographs supplied by the British Columbia Hydro and Power Authority and the U.S. Army Corps of Engineers.

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SUMMARY

The twenty-sixth Annual Report of the Permanent Engineering Board is submitted to the Governments of the United States and Canada in compliance with Article XV of the Columbia River Treaty of 17 January 1961. The status of projects, progress of Entity studies, operation of Duncan, Arrow, Mica and Libby reservoirs, and the resulting benefits are described.

The Duncan, Arrow, Mica and Libby storage projects were operated throughout the year in accordance with the objectives of the Treaty and the terms of operating plans developed by the Entities. Operations under an agreement between the Entities relating to the use of Non-Treaty storage and refill enhancement for Mica and Arrow reservoirs did not conflict with Treaty operations. As a result of more normal natural flows in the basin, Treaty reservoirs were again operated on a daily basis for flood control purposes during the year. (Pages 27-33)

Studies pertaining to development of the hydrometeorological network and power operating plans are being continued by the Entities to ensure operation of projects in accordance with the terms of the Treaty.

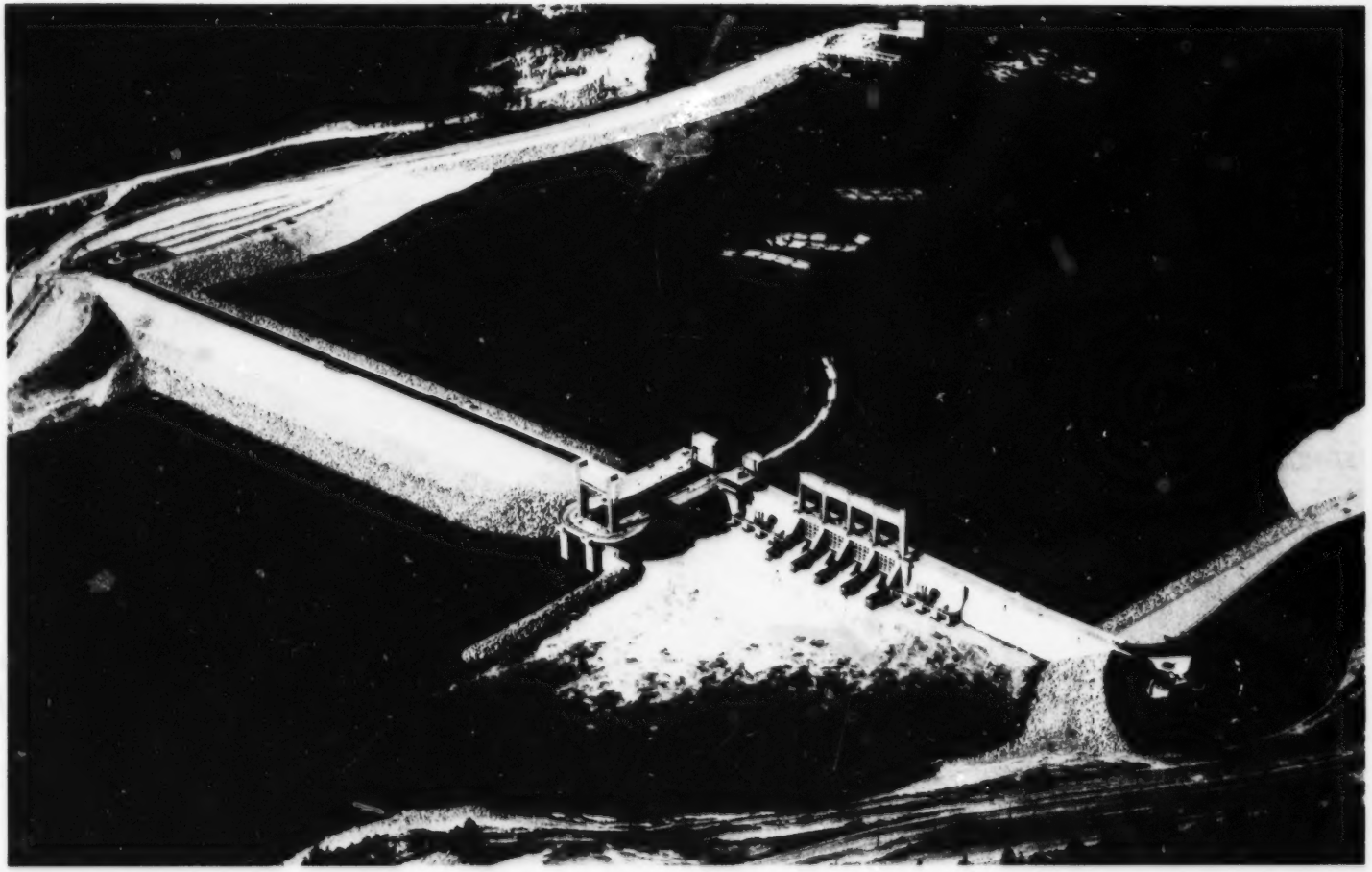
During the 1987-88 report year, the Entities signed two agreements relating to changes in procedures for developing assured operating plans and determining downstream power benefits. These agreements have resolved concerns which the Board had expressed in recent annual reports and have allowed the Entities to complete the Assured Operatng Plan and Determination of Downstream Power Benefits for operating years 1994-95 and 1995-96. The Entities have now returned to the normal completion schedule for these documents. (Pages 21-25)

The board concludes that the objectives of the Treaty are being met.

INTRODUCTION

The Columbia River Treaty, which provides for cooperative development of the water resources of the Columbia River basin, was signed in Washington, D.C. on 17 January 1961 by representatives of the United States and Canada. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties would be to "make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty . . ."

This Annual Report, which covers the period 1 October 1989 to 30 September 1990, describes activities of the Board, progress being achieved by both countries under the terms of the Treaty, operation of the Treaty projects, and the resulting benefits. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included. The report notes that the two major agreements relating to principles of operation and to changes to the procedures for the preparation of Assured Operating Plans and Determination of Downstream Power Benefits, signed in the 1987-88 report year, continue to facilitate the meeting of Treaty objectives. The report provides discussion regarding the operations of the Treaty reservoirs and of the resulting power and flood control benefits, and presents the conclusions of the Board.



HUGH KEENLEYSIDE DAM Columbia River, British Columbia
Concrete spillway and discharge works with navigation lock and earth dam.

THE COLUMBIA RIVER TREATY

General

The Columbia River Treaty was signed in Washington, D.C. on 17 January 1961 and was ratified by the United States Senate in March of that year. In Canada ratification was delayed. Further negotiations between the two countries resulted in formal agreement by an exchange of notes on 22 January 1964 to a Protocol to the Treaty and to an Attachment Relating to Terms of Sale. The treaty and related documents were approved by the Canadian Parliament in June 1964.

The Canadian Entitlement Purchase Agreement was signed on 13 August 1964. Under the terms of this agreement Canada's share of downstream power benefits resulting from the first thirty years of scheduled operation of each of the storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964 the Treaty and Protocol were formally ratified by an exchange of notes between the two governments. The sum of $253.9 million (U.S. funds) was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date at a ceremony at the Peace Arch Park on the International Boundary the Treaty and its Protocol were proclaimed by President Johnson, Prime Minister Pearson, and Premier Bennett of British Columbia.

Features of the Treaty and Related Documents

The essential undertakings of the Treaty are as follows:

(a) Canada will provide 15.5 million acre-feet of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes and Duncan Lake, in British Columbia.

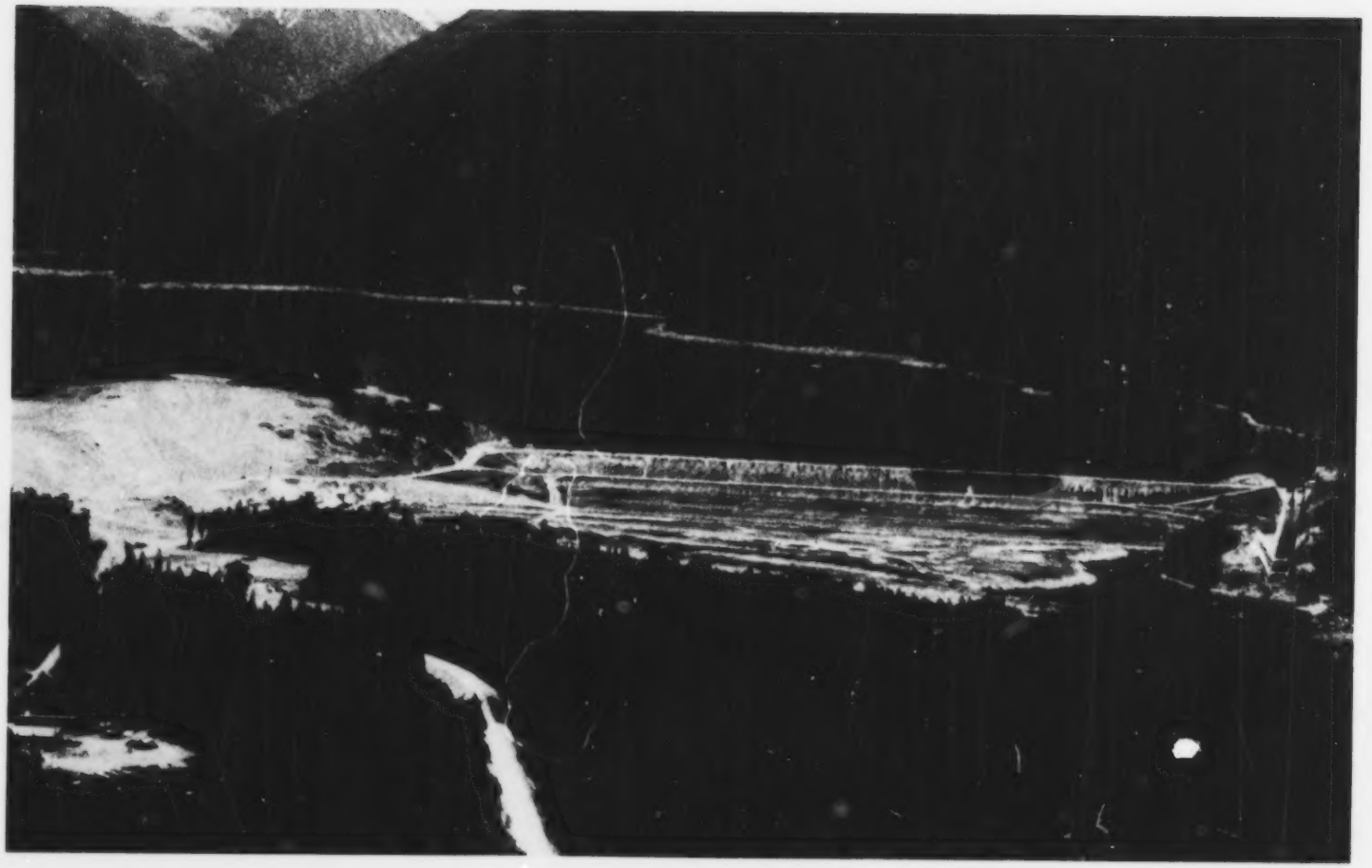
(b) The United States will maintain and operate hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved streamflow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with procedures and operating plans specified in the Treaty.

(c) The United States and Canada will share equally the additional power generated in the United States as a result of river regulation by upstream storage in Canada.

(d) On commencement of the respective storage operations the United States will make payments to Canada totalling $64.4 million (U.S. funds) for flood control provided by Canada.

(e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby reservoir would extend some 42 miles into Canada and Canada would make the necessary Canadian land available for flooding.

(f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984 Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.



DUNCAN DAM — Duncan River, British Columbia
The earth dam with discharge tunnels to the left and spillway to the right.

(g) Differences arising under the Treaty which cannot be resolved by the two countries may be referred by either to the International Joint Commission or to arbitration by an appropriate tribunal as specified by the Treaty.

(h) The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964.

The Protocol of January 1964 amplified and clarified certain terms of the Columbia River Treaty. The Attachment Relating to Terms of Sale signed on the same date established agreement that under certain terms Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Canadian Entitlement Purchase Agreement of 13 August 1964 provided that the Treaty storages would be operative for power purposes on the following dates:

Duncan storage	1 April 1968
Arrow storage	1 April 1969
Mica storage	1 April 1973

PERMANENT ENGINEERING BOARD

General

Article XV of the Columbia River Treaty established a Permanent Engineering Board consisting of two members to be appointed by Canada and two members by the United States. Appointments to the Board were to be made within three months of the date of ratification. The duties and responsibilities of the Board were also stipulated in the Treaty and related documents.

TREATY TOWER
sculpture on Libby Dam

Establishment of the Board

Pursuant to Executive Order No. 11177 dated 16 September 1964 the Secretary of the Army and the Secretary of the Interior on 7 December 1964 appointed two members and two alternate members to form the United States Section of the Permanent Engineering Board. Pursuant to the Department of Energy Organization Act of 4 August 1977 the appointments to the United States Section of the Board are now made by the Secretary of the Army and the Secretary of Energy. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671 dated 29 October 1964. Each member was authorized to appoint an alternate member. On 11 December 1964 the two governments announced the composition of the Board.

The names of Board members, alternate members and secretaries are shown in Appendix A. It is noted that on 27 March 1990, Mr. Herbert H. Kennon succeeded Mr. Lloyd A. Duscha as Chairman of the United States Section of the Board and that, on the same date, Mr. John P. Elmore succeeded Mr. Kennon as an alternate member for the United States. During the report year, Mr. J. Allan was designated as a Board member for Canada to replace Mr. D. H. Horswill.

The names of the current members of the Board's Engineering Committee are also shown in Appendix A.

Duties and Responsibilities of the Board

The general duties and responsibilities of the Board to the governments, as set forth in the Treaty and related documents, include:

(a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada-United States of America boundary;

(b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and if appropriate including in the report recommendations for remedial action and compensatory adjustments;

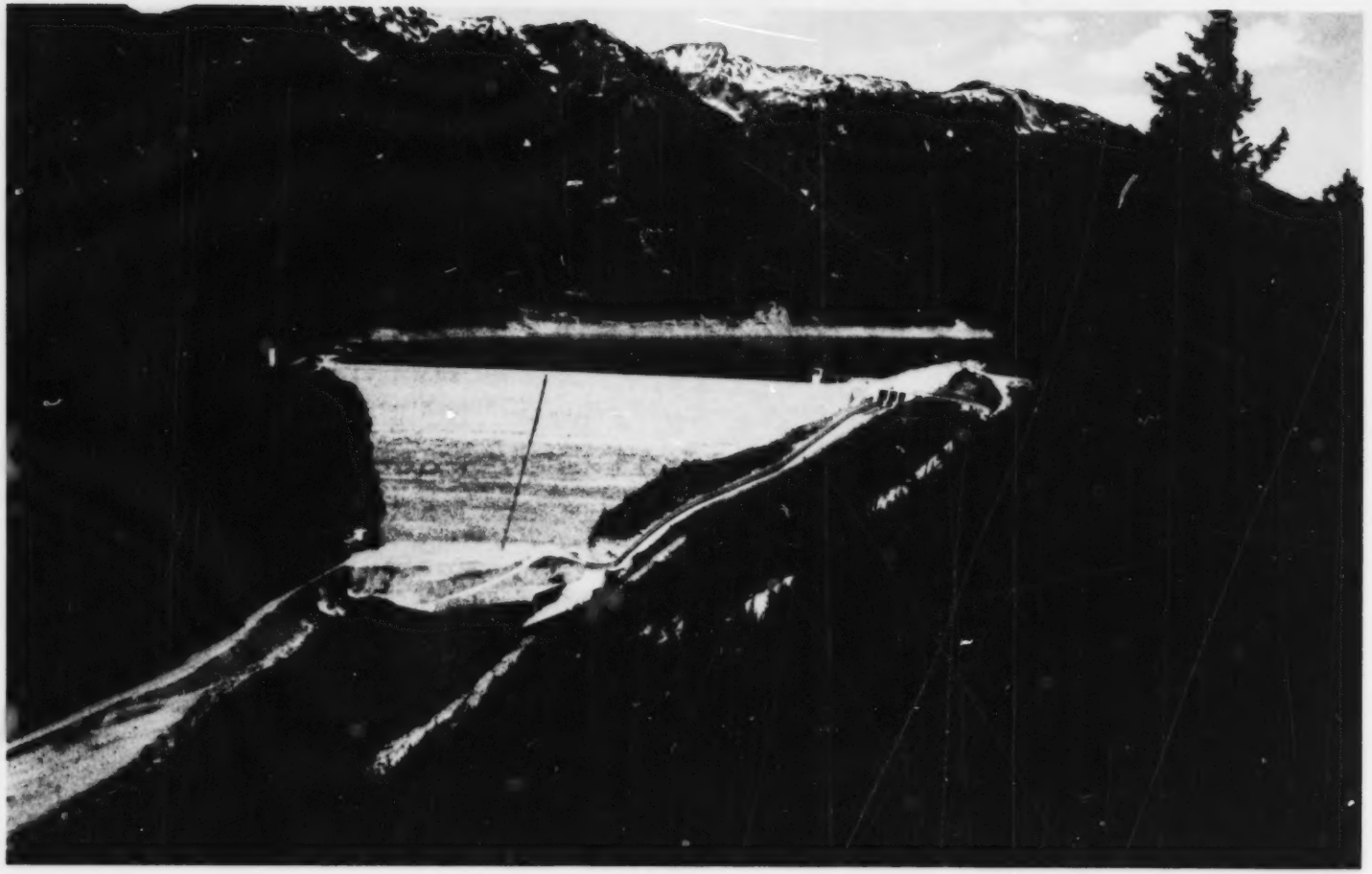
(c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;

(d) making periodic inspections and requiring reports as necessary from the entities with a view to ensuring that the objectives of the Treaty are being met;

(e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter which it considers should be brought to their attention;

(f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America;

(g) consulting with the entities in the establishment and operation of a hydrometeorological system as required by Annex A of the Treaty.



MICA DAM Columbia River, British Columbia
The earth dam showing the spillway at the right. The underground powerhouse is at the left.

ENTITIES

General

Article XIV(1) of the Treaty provides that Canada and the United States shall each designate one or more entities to formulate and execute the operating arrangements necessary to implement the Treaty. The powers and duties of the entities are specified in the Treaty and its related documents.

Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration, Department of the Interior, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of the Army, as the United States Entity with the Administrator to serve as Chairman. Pursuant to the Department of Energy Organization Act of 4 August 1977 the Bonneville Power Administration was transferred to the Department of Energy. Order in Council P.C. 1964-1407 dated 4 September 1964 designated the British Columbia Hydro and Power Authority as the Canadian Entity.

The names of the members of the two Entities are shown in Appendix B.

Power and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents, Article XIV(2) of the Treaty requires that the entities be responsible for:

(a) coordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty,

(b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control,

(c) calculation of the amounts payable to the United States for standby transmission services,

(d) consultation on requests for variations made pursuant to Articles XII(5) and XIII(6),

(e) the establishment and operation of a hydrometeorological system as required by Annex A,

(f) assisting and cooperating with the Permanent Engineering Board in the discharge of its functions,

(g) periodic calculation of accounts,

(h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled,

(i) preparation of proposals to implement Article VIII and carrying out any disposal authorized or exchange provided for therein,

(j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled including such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss,

(k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in Annexes A and B.

Article XIV(4) of the Treaty provides that the two governments may, by an exchange of notes, empower or charge the entities with any other matter coming within the scope of the Treaty.

CLOSING COFFERDAM at Mica Dam in 1967

ACTIVITIES OF THE BOARD

Meetings

The Board met in Portland, Oregon on 30 November 1989 to review progress under the Treaty and to discuss preparation of the Board's Annual Report. The Board met with the Entities on the same day to discuss Entity studies and general progress.

Reports Received

Throughout the report year the Canadian Entity provided the Board with weekly reports on operation of the Canadian storage reservoirs and with daily flow forecasts during the freshet season for the northern part of the Columbia River basin. The United States Entity provided monthly reports on the operation of the Libby storage reservoir. The Entities also provided the following documents and reports and made copies of computer printouts of studies for the Assured Operating Plan and downstream power benefit calculations available for review:

— Annual Report of Columbia River Treaty, Canadian and United States Entities 1 October 1988 through 30 September 1989

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1989 through 31 July 1990 plus a copy of the Entities' agreement on this document

— Updated listings of Columbia River Treaty Hydrometeorological Facilities, November 1989

Subsequent to the end of this report year, the Board received the following documents and reports from the Entities:

— Annual Report of the Columbia River Treaty, Canadian and United States Entities 1 October 1989 through 30 September 1990

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1990 through 31 July 1991, plus a copy of the Entities' agreement on this document, September 1990

— Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1994-95, October 1990

— Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1995-96, October 1990

Report to Governments

The twenty-fifth Annual Report of the Board was submitted to the two governments on 31 December 1989.

LIBBY DAM Kootenai River, Montana
The dam and reservoir, Lake Koocanusa. The powerhouse is at the left of the spillway.

PROGRESS

General

The results achieved under the terms of the Treaty include construction of the Treaty projects, development of the hydrometeorological network, annual preparation of power and flood control operating plans, and the annual calculation of downstream power benefits. The three Treaty storage projects in British Columbia, the Duncan, Arrow and Mica projects, produce power and flood control benefits in both Canada and the United States. The Libby storage project provides power and flood control benefits in both countries. In the United States increased flow regulation provided by Treaty projects has facilitated the installation of additional generating capacity at existing plants on the Columbia River. In Canada completion of the Canal Plant on the Kootenay River in 1976, installation of generators at Mica Dam in 1976-77 and the completion of the Revelstoke project in 1984 have caused power benefits to increase substantially. This amounts to some 4,000 megawatts of generation in Canada that may not have been installed without the Treaty. In addition, the installation of generating capacity at Hugh Keenleyside Dam and at the Murphy Creek Site near Trail, British Columbia is planned for the future.

The Treaty provides Canada with an option, which commenced in 1984, of diverting the Kootenay River at Canal Flats into the headwaters of the Columbia River. The British Columbia Hydro and Power Authority has completed engineering feasibility and detailed environmental studies of the potential diversion.

The locations of the above projects are shown on Plate 1 in Appendix D.

Status of the Treaty Projects

Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled by the Sales Agreement for operation by 1 April 1968 and was the first of the Treaty projects to be completed. It became fully operational on 31 July 1967, well in advance of Treaty requirements.

The earthfill dam, about 130 feet high, is located on the Duncan River a few miles north of Kootenay Lake. The reservoir behind the dam extends for about 27 miles and provides 1,400,000 acre-feet of usable storage which is all committed under the Treaty. There are no power facilities included in this project.

The project is shown in the picture on page 5 and project data are provided in Table 1 of Appendix D.

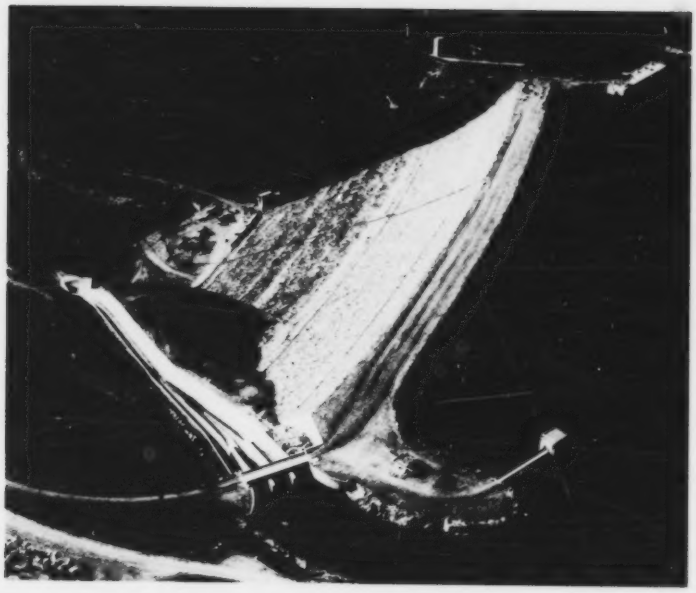
Arrow Project

The Hugh Keenleyside Dam, at the outlet of the Arrow Lakes, was the second Treaty project to be completed. It became operational on 10 October 1968 well ahead of the date of 1 April 1969 scheduled by the Sales Agreement. The project at present has no associated power facilities, however, installation of generators is planned for the future.

The dam consists of two main components: a concrete gravity structure which includes the spillway, low-level outlets and navigation lock and an earthfill section which rises 170 feet above the riverbed. The reservoir, about 145 miles long, includes both the Upper and Lower Arrow Lakes, and provides 7,100,000 acre-feet of Treaty storage.

The project is shown in the picture on page 2 and project data are provided in Table 2 of Appendix D.

DAM AND SPILLWAY
at Mica



Mica Project

Mica Dam, the largest of the Treaty projects, was scheduled by the Sales Agreement for initial operation on 1 April 1973. The project was declared operational and commenced storing on 29 March 1973.

Mica Dam is located on the Columbia River about 85 miles north of Revelstoke, British Columbia. The earthfill dam rises more than 800 feet above its foundation and creates a reservoir 135 miles long, Kinbasket Lake, with a storage capacity of 20,000,000 acre-feet. The project utilizes 12,000,000 acre-feet of live storage of which 7,000,000 acre-feet are committed under the Treaty.

The underground powerhouse has space for a total of six 434 megawatt units with a total capacity of 2,604 megawatts. The first two generators were placed in service late in 1976 and the last of the initial four units commenced operation in October 1977.

The project is shown in the picture on page 10 and project data are provided in Table 3 of Appendix D.

Libby Project in the United States

Libby Dam is located on the Kootenai River 17 miles northeast of the town of Libby, Montana. Construction began in the spring of 1966, storage has been fully operational since 17 April 1973, and commercial generation of power began on 24 August 1975, coincident with formal dedication of the project. The concrete gravity dam rises 370 feet above the riverbed and creates Lake Koocanusa which is 90 miles long and extends 42 miles into Canada. Lake Koocanusa has a gross storage of 5,869,000 acre-feet, of which 4,980,000 acre-feet are usable for flood control and power purposes. The Libby powerhouse, completed in 1976, had four units with a total installed capacity of 420 megawatts.

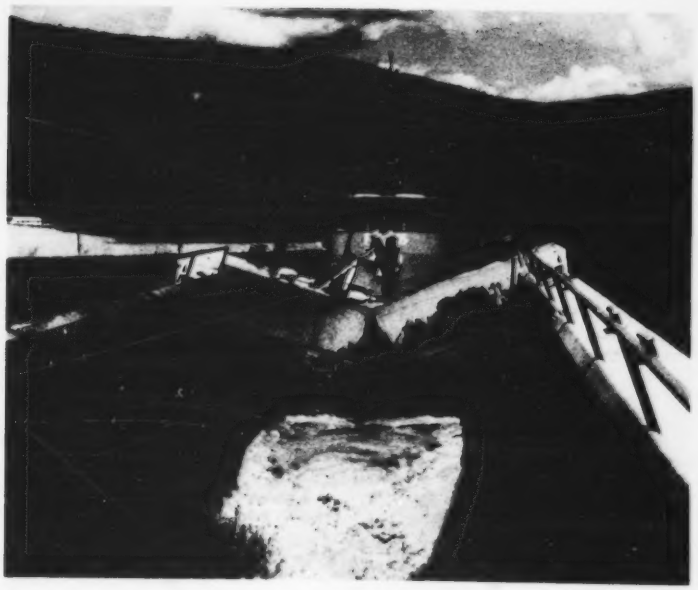
Construction of four additional units was initiated during fiscal year 1978 and the turbines have been installed. However, Congressional restrictions imposed in the 1982 Appropriations Act provide for completion of only one of these units. That unit became available for service late in 1987. The total installed capacity for the five units is 525 megawatts.

The Libby project is shown in the picture on page 16 and project data are provided in Table 4 of Appendix D.

Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 42-mile portion of Lake Koocanusa in Canada. British Columbia Hydro and Power Authority is now responsible for reservoir maintenance, debris clean-up and shoreline activities. The reservoir was nearly full during most of the summer enabling full use of the shoreline area for recreational activities.

BOTTOM DUMPING BARGE
used in construction
of Hugh Keenleyside Dam



Hydrometeorological Network

One of the responsibilities assigned to the Entities by the Treaty is the establishment and operation, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for detailed programming of flood control and power operation. This system includes snow courses, meteorological stations and streamflow gauges. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities, makes recommendations on further development of the Treaty Hydrometeorological System.

In developing the hydrometeorological network, the Entities, with the concurrence of the Board, adopted a document in 1976 which defines the Columbia River Treaty Hydrometeorological System Network and sets forth a method of classifying facilities into those required as part of the Treaty System and those of value as Supporting Facilities. During the 1976-77 report year, the Entities, with the concurrence of the Board, adopted a plan for exchange of operational hydrometeorological data. That plan is still in force.

In the 1985-86 report year the Entities provided the Board with a report "Revised Hydrometeorological Committee Documents" dated November 1985. The list of hydrometeorological facilities included in this document was updated by the Entities in 1987. During this report year a further revision, dated November 1989, of the hydrometeorological facilities which now constitute the network was provided to the Board.

Power Operating Plans and Annual Calculation of Downstream Benefits

The Treaty and related documents provide that the Entities are to agree annually on operating plans and on the resulting downstream power benefits for the sixth succeeding year of operation. These operating plans, prepared five years in advance, are called Assured Operating Plans. They represent the basic commitment of the Canadian Entity to operate the Canadian Treaty storage and provide the Entities with a basis for system planning. Canada's commitment to operate under an Assured Operating Plan is tied directly to the benefits produced by that plan. At the beginning of each operating year, a Detailed Operating Plan which includes Libby reservoir is prepared on the basis of current resources and loads to obtain results that may be more advantageous to both countries than those which would be obtained by operating in accordance with the Assured Operating Plan.

Near the end of the 1987-88 report year the Entities signed two agreements relating to changes in the principles and procedures used in preparing the assured operating plans and in calculating downstream power benefits. These agreements were based on Entity studies of the impact of several proposed changes to Treaty reservoir operating procedures and to the determination of downstream power benefits. Specific changes resulting from the agreements include the use of updated streamflows in all steps of the calculations, updated estimates of irrigation withdrawals and return flows, a revised definition of power loads and generating resources, the use of updated power system operating technology, and consistent application of operating procedures through all steps of the calculations. The Board agrees with the Entities' view that these studies represent the most thorough and complex examination of the technical aspects of the Columbia River Treaty since the ratification in 1964.

The Board also agrees that the changes provided in the two Entity agreements resolved the concerns which the Board had expressed in recent annual reports.

The document "Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1993-94" was provided to the Board at the end of the previous report year. This document follows the same basic approach used in previous years, providing for optimum generation in both countries. It is the second operating plan to be based on the 1988 principles and procedures and, for the first time, includes firm energy shifting as part of the United States optimum operation. Also, although downstream power benefits are based on monthly operation of Treaty storage, for the first time a one-half month shows in the critical period of the Step III studies used for determination of these benefits, a practise on which the Board has reserved judgment. For comparison purposes the document includes an Alternative Operating Plan that excludes energy shifting. The comparison shows that firm energy shifting creates benefits to both countries and provides an increase of 19.8 megawatts of average annual usable energy and a decrease of 6.9 megawatts of dependable capacity. The United States Entity will deliver this energy to the Canadian Entity during the 1993-94 operating year and will have the option of selecting either the Plan or the Alternative for use in the Detailed Operating Plan. The Entities are considering how energy shifting will apply after termination of the Sales Agreement and are reviewing the use of half months in the determination of benefits.

The assured operating plan and the determination of downstream power benefits documents for operating years 1994-95 and 1995-96 were provided by the Entities after the end of the current report year and are currently under review by the Board. For each operating year both an Assured Operating Plan and an Alternative Operating Plan are provided. The Entities have now returned to the normal completion schedule for these documents.

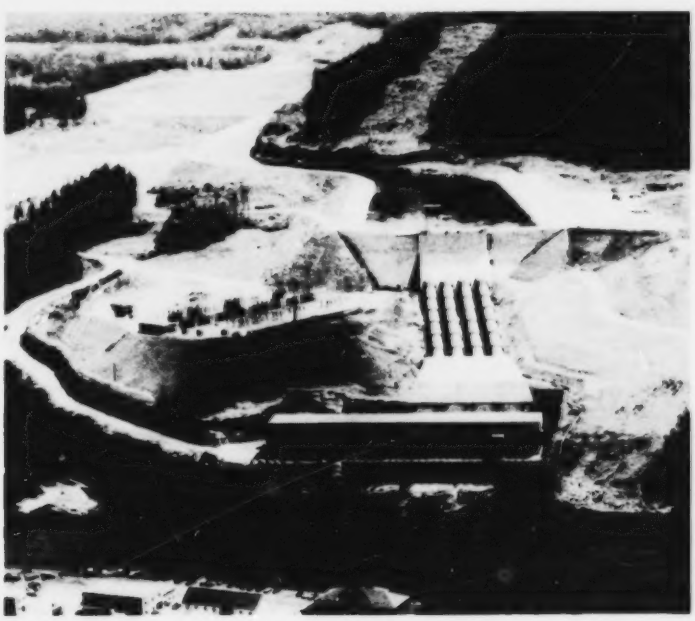
The Board notes that the document for operating year 1997-98, normally completed by the fall of 1992, will determine a Canadian power entitlement, from Duncan reservoir storage, not covered by the existing Sales Agreement. The Entities are currently discussing the mechanisms for returning entitlements to downstream benefits.

Early in this report year the Entities provided the Board with the Detailed Operating Plan for Canadian Treaty storage and Libby reservoir for the operating year ending 31 July 1990. The Detailed Operating Plan for the operating year ending 31 July 1991 was forwarded to the Board after the end of the report year. These plans contain criteria for operating the Arrow, Duncan, Mica and Libby reservoirs.

In April 1984, the Entities reached a long term storage agreement relating to the initial filling of non-Treaty reservoirs, the use of non-Treaty storage, and Mica and Arrow reservoir refill enhancement. This agreement remained in effect throughout the report year. Operations under the agreement did not interfere with Treaty operations or Treaty objectives.

During this report year the Entities signed an expanded and extended non-Treaty Storage Agreement which is scheduled for implementation in the new report year.

KOOTENAY CANAL PLANT
made possible by Treaty storage



The Northwest Power Planning Council was established by Act of Congress in 1980 to prepare a program for improvement of fish and wildlife in the Columbia River Basin and to develop a conservation and electric power plan for the Pacific Northwest. The Council, on 15 November 1982, adopted the Columbia River Basin Fish and Wildlife Program which establishes a water budget. This budget reserves 3.45 million acre-feet of storage upstream from Priest Rapids Dam on the Columbia River and 1.19 million acre-feet upstream from Lower Granite Dam on the Snake River. This storage is used by United States' project operators when it is required to improve low flows in the main rivers during the downstream migration of anadromous fish. Fisheries and native Indian interests control use of the storage for this purpose. The use of Canadian Treaty storage is advocated by the United States Northwest Power Planning Council in its Fish and Wildlife Program.

With regard to the use of Canadian Treaty storage to meet water budget purposes, the Board has stated in previous reports that the assured operating plans are to provide for optimum operation for power and flood control. The Board has also noted, however, that the Entities may agree to provide water for fish migration under detailed operating arrangements providing this does not conflict with Treaty requirements.

Flood Control Operating Plans

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada.

The Columbia River Treaty Flood Control Operating Plan defines flood control operation of the Duncan, Arrow, Mica and Libby reservoirs. This plan was received from the Entities and reviewed by the Board in the 1972-73 report year and is still in effect.

DUNCAN PROJECT
nearing completion in 1967

Flow Records

Article XV(2)(a) of the Treaty specifies that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay Rivers at the Canada-United States of America boundary. Flows for this report year are tabulated in Appendix C for the Kootenai River at Porthill, Idaho and for the Columbia River at Birchbank, British Columbia.

OPERATION

General

The Columbia River Treaty Operating Committee was established by the Entities to develop operating plans for the Treaty storages and to direct operation of these storages in accordance with the terms of the Entity agreements.

During the report year the Treaty storage in Canada was operated by the Canadian Entity in accordance with:

— Columbia River Treaty Flood Control Operating Plan

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1989 through 31 July 1990

— Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1989-90

— Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1990-91.

In addition, the following agreements were in effect during this period:

— An agreement between the Entities dated 9 April 1984 relating to:

  — Agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration Relating to: (1) Initial Filling of Non-Treaty Reservoirs, (2) The Use of Columbia River Non-Treaty Storage and (3) Mica and Arrow Reservoir Refill Enhancement

  — Contract between Bonneville Power Administration and Mid-Columbia Purchasers Relating to Federal and Canadian Columbia River Storage

— Columbia River Treaty Entity Agreement on Principles for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefits, July 1988

— Columbia River Treaty Entity Agreement on Changes to Procedures for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefit Studies, August 1988.

Power Operation

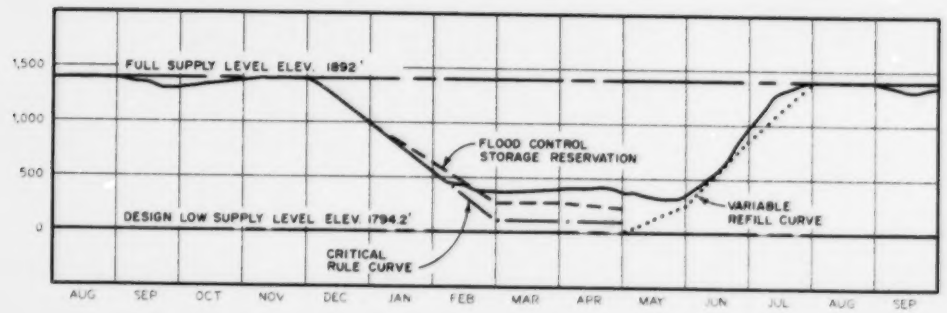
The three Canadian Treaty reservoirs, Duncan, Arrow and Mica, and the Libby reservoir in the United States were in full operation throughout this report year.

The total Treaty storage volume did not quite fill during the summer of 1989 as Arrow reservoir peaked at 1442.9 feet and provided about 98 percent of its Treaty storage. At the beginning of this report year, drafting had started at both the Arrow and Duncan projects. Significant drafting of Treaty storage at the Mica project began in November. As a result of improved runoff conditions the total Treaty storage volume filled during the 1990 freshet.

Although 1990 was again a year of below average runoff for the Columbia River at The Dalles, runoff was significantly greater than in the previous three years. In fact, runoff upstream from Grand Coulee was slightly above normal.

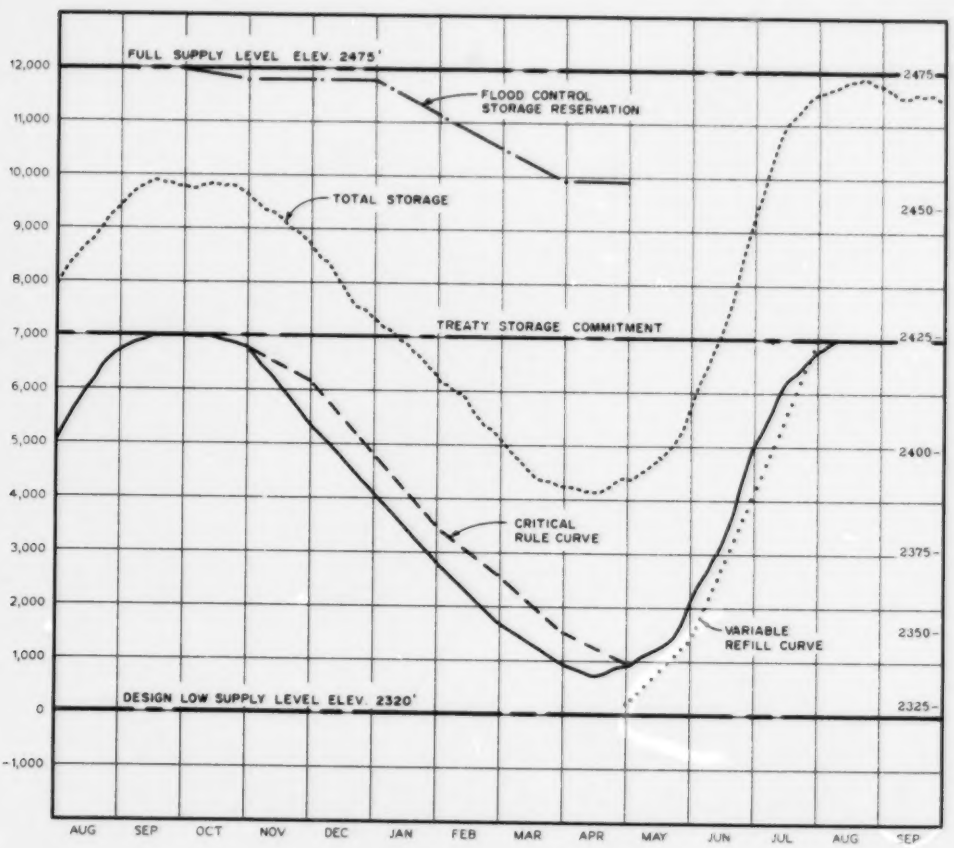
Low reservoir levels at the beginning of the year resulted in the coordinated reservoir system being operated to meet proportional drafting requirements until the end of December. As a result of improved water supply forecasts at that time, proportional drafting was not required after December.

During the year some storage was transferred between the Treaty reservoirs. These storage transfers were accomplished without disrupting Treaty operations.



DUNCAN RESERVOIR

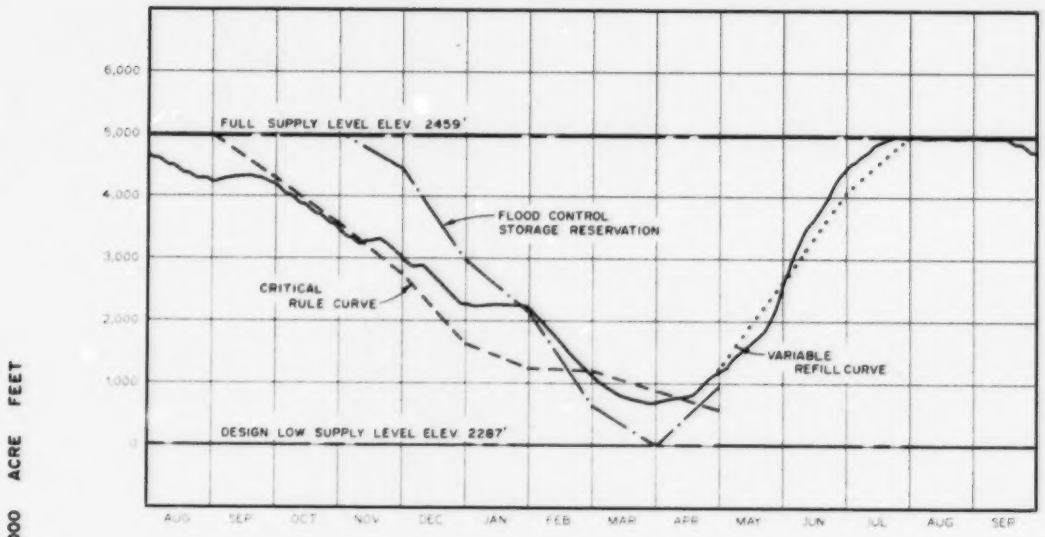
USABLE RESERVOIR STORAGE IN 1,000 ACRE FEET



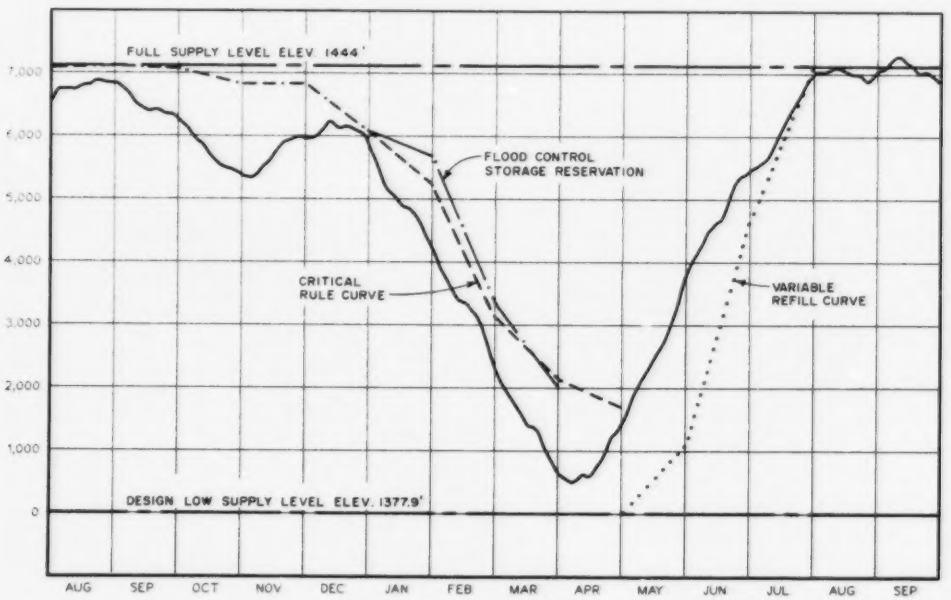
ELEVATION IN FEET (not applicable to Treaty Storage)

MICA RESERVOIR

HYDROGRAPHS — Duncan and Mica reservoir levels for the 14-month period ending 30 September 1990.



LIBBY RESERVOIR



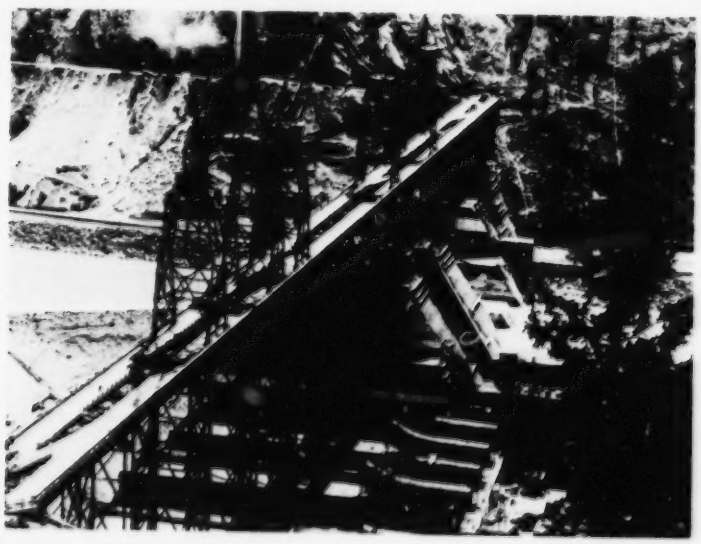
ARROW RESERVOIR

HYDROGRAPHS — Libby and Arrow reservoir levels for the 14-month period ending 30 September 1990.

Commencing in the 1984 report year, operation in the United States incorporated requirements of the Northwest Power Planning Council's Fish and Wildlife Program. This program specifies a water budget for use during the period 15 April to 15 June to meet minimum flow requirements for the downstream migration of anadromous fish. In this report year water budget releases on the mid-Columbia occurred between 14 and 28 May. After 28 May, further water budget requests were not necessary as warmer weather resulted in a major increase in natural flows.

Operation of the reservoirs is illustrated on pages 29 and 30 by hydrographs which show actual reservoir levels and some of the more important rule curves which govern operation of the Treaty storages. The Flood Control Storage Reservation curve specifies maximum month-end reservoir levels which will permit evacuation of the reservoir to control the forecast freshet. The Critical Rule Curve shows minimum month-end reservoir levels which should be maintained to enable the anticipated power demands to be met under adverse water supply conditions. The Variable Refill Curve shows reservoir elevations necessary to ensure refilling the reservoir by the end of July with a reasonable degree of confidence. Similar rule curves which apply to operation of the combined Canadian Treaty storages have also been provided to the Board.

CONSTRUCTION
at Libby Dam



At the beginning of the report year Duncan reservoir had been drafted to elevation 1886.6 feet, 5.4 feet below normal full pool. Releases were curtailed to minimum discharge and the reservoir refilled to full pool by 9 November. The project passed inflow until early December and remained at full pool. Drafting the reservoir started on 9 December and continued until early February when releases were gradually reduced to 1000 cfs by 21 February to avoid exceeding the International Joint Commission rule curve for Kootenay Lake. By the end of February, Duncan reservoir was about 20 feet above its flood control rule curve as a result of this constraint. The reservoir was drafted to its lowest elevation of 1822.7 feet by 23 May, about 28.5 feet above its design minimum level of 1794.2 feet.

Discharge was reduced to 100 cfs on 1 June and the reservoir refilled to its full pool elevation of 1892 feet on 31 July and started to pass inflow. At the end of September the reservoir was at elevation 1889.1 feet.

Arrow reservoir had been drafted to elevation 1438.3 feet, 5.7 feet below its full pool level, at the beginning of the report year. Drafting continued until early November when the reservoir refilled about five feet as a result of high inflows and reduced draft requirements. The reservoir remained close to elevation 1435 feet until the end of December. Drafting began early in January and continued until 6 April when the reservoir reached its lowest elevation at 1385 feet, about 7 feet above its minimum pool level.

After mid-April the reservoir filled quickly to full pool elevation, 1444.0 feet, on 31 July. The reservoir was surcharged and reached its highest elevation, 1446.0 feet, on 11 September. At year end the reservoir was at elevation 1442.5 feet.

Mica reservoir was at elevation 2453.3 feet, 21.7 feet below full pool level, at the start of the report year. Drafting Treaty storage was started in October to meet flood control rule curve requirements and continued until 17 April when the reservoir reached its lowest elevation at 2398.6 feet.

The reservoir began filling on 18 April. Treaty storage filled on 10 August and remained full through September. The reservoir reached its highest elevation of 2474.1 feet on 23 August. This was the highest elevation reached since the reservoir last filled in August 1986. At the end of the report year the reservoir was at elevation 2470.2 feet. Non-Treaty storage operation did not interfere with the use of Treaty storage.

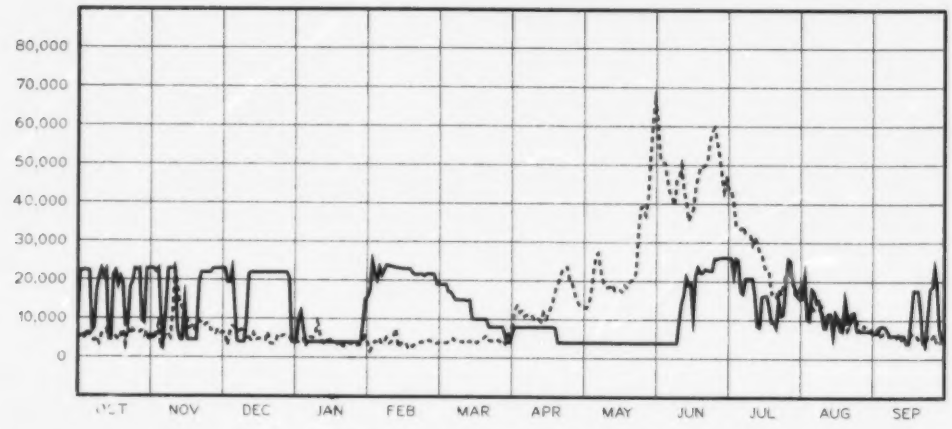
At the start of the report year Libby reservoir had been drafted to elevation 2441.7 feet. Drafting continued from early October until the end of December when the water supply forecast indicated proportional drafting was no longer necessary. Only minor drafting occurred in January to meet flood control requirements. Heavier drafting resumed in February for flood control purposes as a result of a higher water supply forecast and continued until the reservoir reached its lowest elevation at 2325.5 feet on 30 March. The rate of drafting had to be reduced in early March in order to avoid forcing the level of Kootenay Lake to exceed the International Joint Commission rule curve.

Reservoir inflows began rising in mid-April and the reservoir filled to elevation 2459.0 feet, within one foot of full pool level, by 22 July. The reservoir was operated within the range 2458.5 to 2459.0 from 24 July through 10 September. At the end of the report year the reservoir was at elevation 2453.6 feet.

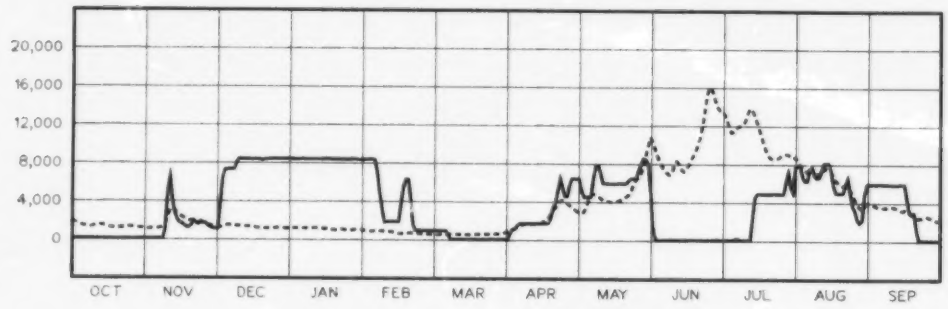
Flood Control Operation

During the 1990 freshet flood control was provided by normal refill of Treaty projects and other storage reservoirs in the Columbia River basin. Daily operation of reservoirs for flood control was in effect from 30 May to 19 June, the first time that daily operation has been in effect since 1986. The freshet was controlled to well below damaging level.

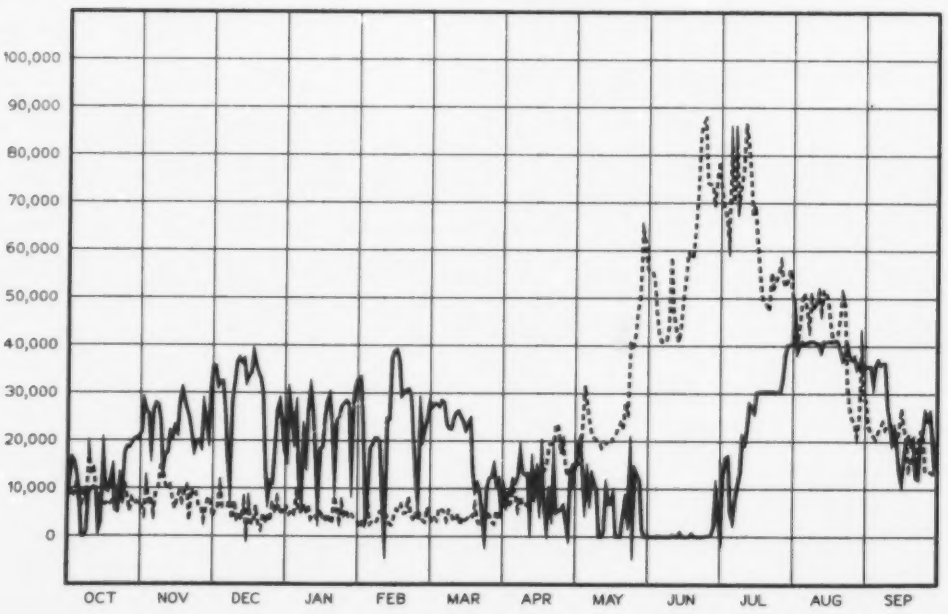
DISCHARGE IN CUBIC FEET PER SECOND



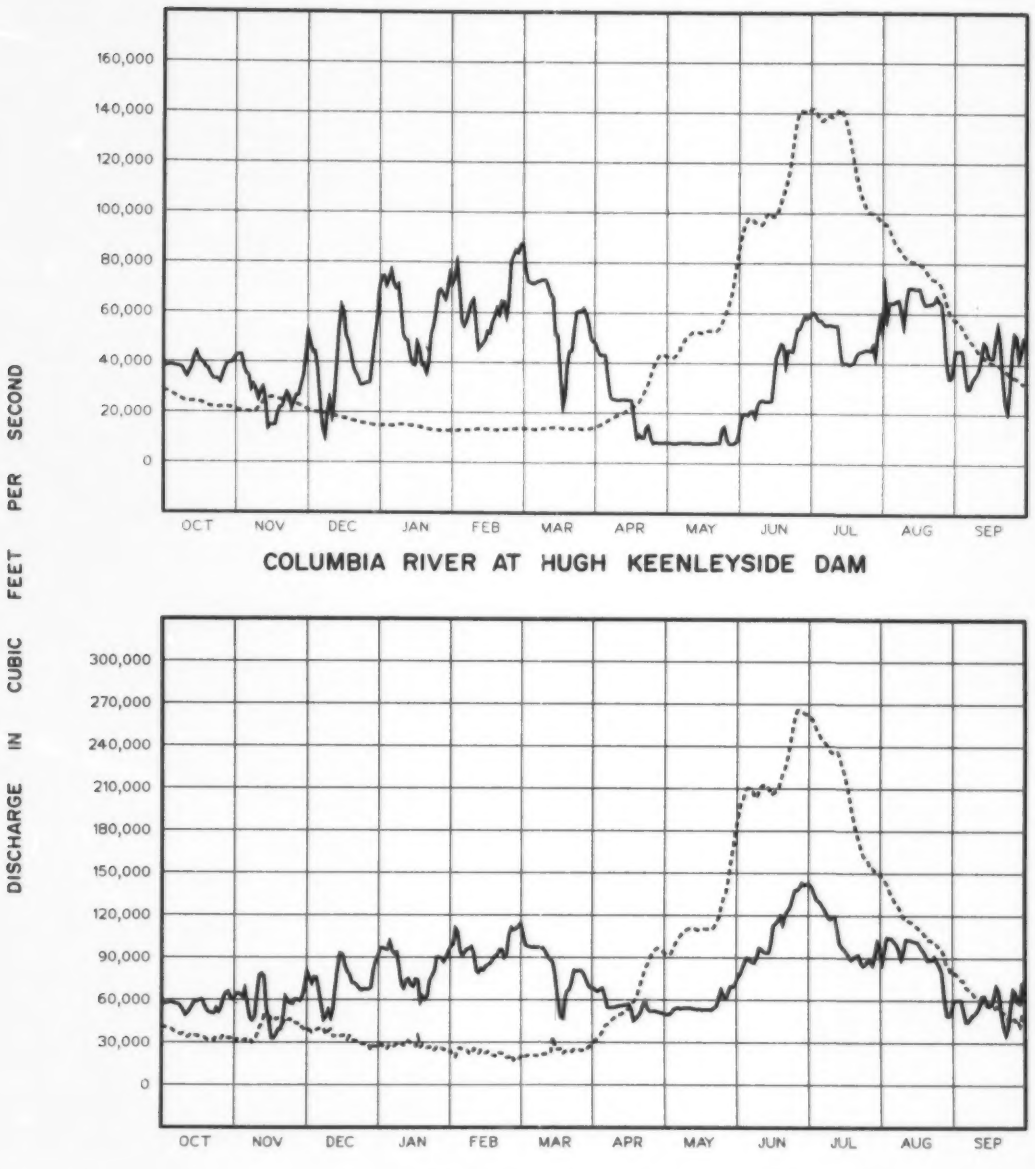
KOOTENAI RIVER AT LIBBY DAM



DUNCAN RIVER AT DUNCAN DAM



COLUMBIA RIVER AT MICA DAM



HYDROGRAPHS — Observed and pre-project flows for year ending 30 September 1990.

BENEFITS

Flood Control Provided

Without regulation by upstream reservoirs, the 1990 freshet would have produced average freshet levels at Trail, British Columbia and at The Dalles, Oregon and would have caused minor flood damage in the United States.

It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by about five feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about eleven and one-half feet. The effect of storage in the Duncan, Arrow, Mica and Libby reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on page 34 by hydrographs which show both the actual discharges and the flows that would have occurred if the dams had not been built. It is noted that the hydrograph showing pre-project conditions for Birchbank has been computed on the assumption that the effects of Duncan, Arrow, Mica and Libby regulation and of the regulation provided by the Corra Linn development on Kootenay Lake have been removed.

The operation of Columbia Basin reservoirs for the system as a whole reduced the natural annual peak discharge of the Columbia River near The Dalles, Oregon from about 511,000 cfs to 371,900 cfs.

All payments required by Article VI(1) as compensation for flood control provided by the Canadian Treaty storage have been made by the United States to Canada; the final payment was made on 29 March 1973 when the Mica project was declared operational.

Power Benefits

Downstream power benefits in the United States which arise from operation of the Canadian Treaty storage were pre-determined for the first thirty years of operation of each

BOATS IN LOCK
at Hugh Keenleyside Dam

project and the Canadian one-half share was sold in the United States under the terms of the Canadian Entitlement Purchase Agreement. The United States Entity delivers capacity and energy to Columbia Storage Power Exchange participants as purchasers of the Canadian Entitlement. The benefits of additional generation made possible on the Kootenay River in Canada as a result of regulation provided by Libby, and generation at the Mica and Revelstoke projects, are retained wholly within Canada. The benefits from Libby regulation which occur downstream in the United States are not shareable under the Treaty.

The Canadian Entitlement Purchase Agreement terminates in stages beginning in 1998. Accordingly, downstream benefits are returnable to Canada as of the following dates:

Duncan storage	1 April 1998
Arrow storage	1 April 1999
Mica storage	1 April 2003

After 1 April 2003, Canada's share of downstream benefits is fully returnable.

Other Benefits

By agreement between the Entities, as in previous report years, streamflows were regulated for non-power purposes such as accommodating construction in river channels and providing water to assist the downstream migration of juvenile fish in the United States. These arrangements were implemented under the Detailed Operating Plan and provided mutual benefits to the Entities.

CONCLUSIONS

1. The Duncan, Arrow, Mica and Libby projects have been operated in conformity with the provisions of the Treaty. Operation reflected detailed operating plans developed by the Entities, the flood control operating plan for Treaty reservoirs, and an agreement between the Entities relating to the use of non-Treaty storage and refill enhancement of Mica and Arrow reservoirs. Operation under this agreement did not conflict with normal Treaty operations.

2. The Entities have reached agreement on the Detailed Operating Plan for Columbia River Treaty Storage for 1990-91.

3. Entity evaluations pertaining to development of the hydrometeorological network, power operating plans, and the calculation of downstream power benefits are proceeding. The Assured Operating Plan and the Determination of Downstream Power Benefits for operating years 1994-95 and 1995-96 have been received and the Entities have now returned to the normal completion schedule for these documents.

4. The two Entity agreements signed in the 1987-88 report year resolved concerns which the Board had expressed in recent annual reports. They clarified operating procedures and how downstream power benefits will be calculated. The agreements resolved issues which had been under discussion for several years and facilitate meeting Treaty objectives.

5. The objectives of the Treaty are being met.

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

United States	Canada
Members	
Mr. Herbert H. Kennon, Chairman 1) Deputy Directory, Directorate of Civil Works, H.Q., U.S. Army Corps of Engineers, Washington, D.C.	Mr. G.M. MacNabb, Chairman R.R. #2, North Gower, Ontario
Mr. Ronald H. Wilkerson 4655 Highway 200 East, Missoula, Montana	Mr. J. Allan 3) Deputy Minister, Ministry of Energy, Mines and Petroleum Resources, Victoria, B.C.
Alternates	
Mr. John P. Elmore 2) Chief, Operations, Construction and Readiness Division, Directorate of Civil Works, H.Q., U.S. Army Corps of Engineers, Washington, D.C.	Mr. E.M. Clark 4376 Starlight Way, North Vancouver, B.C.
Mr. Thomas L. Weaver Assistant Administrator for Engineering, Western Area Power Administration, Department of Energy, Golden, Colorado	Dr. D.A. Kasianchuk Comptroller of Water Rights, Ministry of Environment, Victoria, B.C.
Secretaries	
Mr. S.A. Zanganeh Hydraulics and Hydrology Branch, Directorate of Civil Works, H.Q., U.S. Army Corps of Engineers, Washington, D.C.	Mr. E.M. Clark 4376 Starlight Way, North Vancouver, B.C.

1) Vice Mr. L.A. Duscha as of 27 March 1990
2) Vice Mr. H.H. Kennon as of 27 March 1990
3) Designated to replace Mr. D.H. Horswill

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

Record of Membership

Members

United States		Canada	
Mr. Wendell E. Johnson 1)	1964-1970	Mr. G.M. MacNabb 1)	1964-
Mr. Morgan E. Dubrow	1964-1970	Mr. A.F. Paget	1964-1973
Mr. John W. Neuberger	1970-1973	Mr. V. Raudsepp	1973-1974
Mr. Joseph B. Caldwell 1)	1971-1973	Mr. B.E. Marr	1974-1987
Mr. Homer B. Wills 1)	1973-1979	Mr. T.R. Johnson	1987-1988
Mr. C. King Mallory	1973-1975	Mr. D.H. Horswill	1989-
Mr. Raymond A. Peck, Jr.	1976-1977	Mr. J. Allan 2)	1990-
Mr. J. Emerson Harper	1978-1988		
Mr. Lloyd A. Duscha 1)	1979-1990		
Mr. Ronald H. Wilkerson	1988-		
Mr. Herbert H. Kennon 1)	1990-		

Alternates

Mr. Fred L. Thrall	1964-1974	Mr. E.M. Clark	1964-
Mr. J. Emerson Harper	1964-1978	Mr. J.T. Rothwell	1964-1965
Mr. Alex Shwaiko	1974-1987	Mr. H.M. Hunt	1966-1988
Mr. Thomas L. Weaver	1979-	Dr. D.A. Kasianchuk	1988-
Mr. Herbert H. Kennon	1987-1990		
Mr. John P. Elmore	1990-		

Secretaries

Mr. John W. Roche	1965-1969	Mr. E.M. Clark	1964-
Mr. Verle Farrow	1969-1972		
Mr. Walter W. Durican	1972-1978		
Mr. S.A. Zanganeh	1978-		

1) Chairman
2) Designated to replace Mr. D.H. Horswill

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD
ENGINEERING COMMITTEE

Current Membership

United States	Canada
Members	
Mr. S.A. Zanganeh, Chairman Hydraulics and Hydrology Branch Directorate of Civil Works H.Q., U.S. Army Corps of Engineers Washington, D.C.	Mr. R.O. Lyons, Chairman Inland Waters Directorate Environment Canada North Vancouver, B.C.
Mr. G.L. Fuqua Office of Energy Resources Bonneville Power Administration Portland, Oregon	Mr. D.M. McCauley Electrical Energy Branch Energy, Mines and Resources Canada Ottawa, Ontario
	Mr. B. Stipdonk Energy Resources Division Ministry of Energy, Mines and Petroleum Resources Victoria, B.C.
Alternates	
Mr. E.E. Eiker Hydraulics and Hydrology Branch Directorate of Civil Works H.Q., U.S. Army Corps of Engineers Washington, D.C.	Mr. S.J. Wright Bonneville Power Administration Department of Energy Washington, D.C.

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

United States	Canada
Members	
Mr. James J. Jura, Chairman Administrator, Bonneville Power Administration, Department of Energy, Portland, Oregon	Mr. L.I. Bell, Chairman Chairman, British Columbia Hydro and Power Authority, Vancouver, B.C.
Brigadier General Pat M. Stevens, IV Division Engineer, U.S. Army Engineer Division, North Pacific, Portland, Oregon	

APPENDIX C

RECORD OF FLOWS

AT THE

INTERNATIONAL BOUNDARY

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	9,740	23,800	25,900	6,960	17,000	23,600	11,200	14,500	23,900	35,600	17,100	7,900
2	12,200	24,000	25,900	7,100	21,400	21,800	13,100	14,200	24,700	34,900	16,700	7,840
3	21,300	24,200	25,600	12,300	26,100	21,400	19,100	14,300	23,300	33,900	18,100	7,880
4	22,600	23,700	22,500	13,200	22,800	21,500	22,900	15,100	24,500	32,000	21,500	8,000
5	22,700	24,800	29,900	9,010	22,000	21,500	23,300	17,100	25,000	29,000	12,700	9,000
6	22,800	11,700	36,200	6,500	25,000	21,200	22,400	20,600	23,000	31,700	11,500	9,140
7	19,000	6,300	21,100	6,940	23,800	19,600	21,500	22,300	23,500	28,600	17,800	9,120
8	8,630	15,300	11,800	7,730	25,000	19,300	21,300	20,300	24,900	22,300	17,800	8,390
9	10,200	24,000	10,500	8,080	25,900	18,400	22,100	17,800	22,300	21,400	15,400	7,200
10	16,800	26,700	9,760	13,000	26,100	17,900	21,700	16,200	22,400	24,500	15,500	7,080
11	21,800	32,800	9,040	15,400	26,400	17,800	20,900	15,600	22,900	24,500	13,400	7,050
12	21,800	37,800	15,900	12,200	27,300	17,900	19,600	15,600	27,100	24,200	9,860	6,940
13	22,200	22,000	25,100	10,700	27,100	17,800	19,400	16,000	31,000	23,800	9,160	7,070
14	19,900	13,600	26,000	9,840	26,100	17,800	19,500	16,400	32,100	19,600	12,300	7,030
15	7,050	11,500	25,900	9,240	25,800	17,300	20,000	16,300	33,900	12,200	12,300	7,000
16	8,860	17,800	25,800	8,880	26,100	16,800	20,900	15,700	33,300	11,200	8,070	5,620
17	21,200	9,520	25,900	8,490	26,100	13,400	22,100	15,300	33,400	17,600	11,900	5,590
18	20,400	8,560	25,600	7,880	25,900	12,800	22,700	15,500	26,400	18,200	11,400	11,000
19	20,300	8,170	25,300	7,650	25,700	13,000	24,400	15,300	36,100	18,200	9,030	17,000
20	20,800	8,310	24,500	7,430	25,100	13,500	26,100	15,300	38,700	15,600	8,910	18,000
21	19,300	9,850	24,400	7,400	24,300	14,600	26,500	15,400	37,300	11,800	15,400	18,000
22	10,300	23,000	24,300	7,400	24,400	15,600	24,800	15,300	37,600	11,500	12,900	13,300
23	10,000	25,300	24,300	7,220	24,600	15,500	24,700	16,100	37,000	10,500	10,400	6,410
24	19,300	25,500	24,300	7,190	24,700	13,700	24,600	18,700	37,000	15,800	12,200	5,960
25	22,800	25,600	24,400	6,900	24,400	13,000	23,600	21,700	36,300	13,500	12,400	10,600
26	24,000	25,600	24,300	7,100	24,400	12,900	21,600	24,000	37,700	14,400	9,050	17,600
27	24,100	25,400	24,000	6,740	24,300	12,800	19,300	22,800	38,300	23,600	8,540	21,100
28	21,900	25,900	23,900	6,700	24,200	12,700	17,900	21,800	37,000	28,200	8,440	23,600
29	10,800	25,900	23,700	6,830		12,700	16,700	22,800	36,400	25,400	8,420	18,400
30	12,400	25,800	19,600	10,400		12,800	15,400	24,600	35,800	22,000	8,010	9,820
31	22,600		8,030	16,100		12,500		24,600		19,900	8,000	
Mean	17,670	20,430	22,370	8,984	24,710	16,550	20,980	17,970	30,760	21,790	12,390	10,630

KOOTENAI RIVER AT PORTHILL, IDAHO — Daily discharges for the year ending 30 September 1990 in cubic feet per second.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	57,900	63,600	80,500	96,800	99,300	112,000	68,500	50,800	71,700	142,000	95,100	60,400
2	57,600	64,900	75,900	97,100	111,000	114,000	68,500	50,200	76,200	142,000	86,900	60,400
3	57,500	64,400	71,700	96,000	108,000	107,000	67,200	49,700	78,400	140,000	96,800	60,200
4	58,200	62,500	76,400	95,700	94,700	99,000	66,100	49,700	82,800	136,000	105,000	60,300
5	58,600	68,000	76,000	101,000	91,200	98,200	67,500	50,900	87,700	131,000	104,000	54,100
6	57,800	57,400	66,500	95,000	93,900	97,300	68,500	53,600	90,000	130,000	104,000	45,000
7	57,300	47,400	56,500	92,700	95,900	97,200	63,000	54,500	88,500	129,000	102,000	45,000
8	57,100	45,400	46,100	93,600	96,500	97,400	54,900	54,300	86,700	125,000	99,800	47,200
9	55,600	48,000	48,500	82,500	97,700	97,200	54,500	54,200	86,400	123,000	96,100	49,700
10	52,800	64,200	53,100	70,200	92,500	97,600	54,700	54,300	90,600	119,000	89,200	50,900
11	49,100	77,700	47,300	68,300	80,700	96,500	54,600	54,300	97,300	117,000	95,100	52,800
12	51,000	78,700	54,000	74,300	79,200	96,600	55,300	54,300	96,000	118,000	103,000	56,800
13	53,800	76,700	69,500	75,300	82,200	94,000	55,700	54,400	94,200	119,000	103,000	63,200
14	56,600	53,600	83,700	70,500	80,900	90,500	55,800	54,100	93,700	110,000	103,000	63,100
15	59,800	45,400	93,200	69,700	83,800	88,500	56,600	53,700	93,500	100,000	102,000	57,900
16	58,900	33,100	92,100	75,000	84,600	86,600	56,400	53,500	100,000	97,900	102,000	56,800
17	60,500	33,000	84,300	74,000	85,700	76,900	57,100	53,700	113,000	96,000	102,000	57,300
18	60,500	35,700	80,000	58,700	88,200	61,100	53,800	53,100	115,000	93,800	98,300	63,000
19	56,100	39,400	78,000	62,900	91,100	48,200	45,300	53,300	117,000	91,000	95,600	70,400
20	52,800	39,700	72,100	60,600	92,300	46,900	46,500	53,300	120,000	88,600	93,000	66,900
21	51,100	48,200	72,000	63,100	95,700	60,200	48,700	53,400	114,000	90,400	88,500	52,100
22	50,300	62,300	70,500	74,200	95,800	66,400	51,400	53,000	121,000	91,500	88,700	41,800
23	50,500	59,200	68,000	77,000	89,800	67,400	56,700	54,700	124,000	92,200	88,800	35,500
24	54,400	57,500	66,800	80,500	92,300	73,100	59,800	55,800	126,000	86,400	90,900	41,100
25	51,400	57,300	67,700	90,300	107,000	81,300	53,800	62,300	132,000	84,400	87,700	55,800
26	55,500	60,800	67,900	90,400	112,000	80,700	51,800	67,300	138,000	86,000	84,500	68,000
27	62,100	60,200	67,300	89,700	109,000	80,800	52,200	62,600	138,000	88,300	79,800	66,000
28	65,300	59,500	69,000	87,000	111,000	80,900	52,400	61,100	140,000	87,800	61,600	59,400
29	66,000	62,300	81,400	90,200		78,700	51,700	65,500	144,000	85,300	49,600	58,100
30	61,500	69,300	87,500	94,100		74,900	51,100	70,000	142,000	92,300	49,200	73,200
31	60,500		91,100	97,800		70,200		69,700		101,000	52,100	
Mean	56,700	56,500	71,400	82,100	94,400	84,400	56,700	56,000	107,000	108,000	90,200	56,400

COLUMBIA RIVER AT BIRCHBANK, B.C. — Daily discharges for the year ending 30 September 1990 in cubic feet per second.

APPENDIX D

PROJECT INFORMATION

Power and Storage Projects,
Northern Columbia Basin — Plate No. 1

Project Data
Duncan Project — Table No. 1
Arrow Project — Table No. 2
Mica Project — Table No. 3
Libby Project — Table No. 4

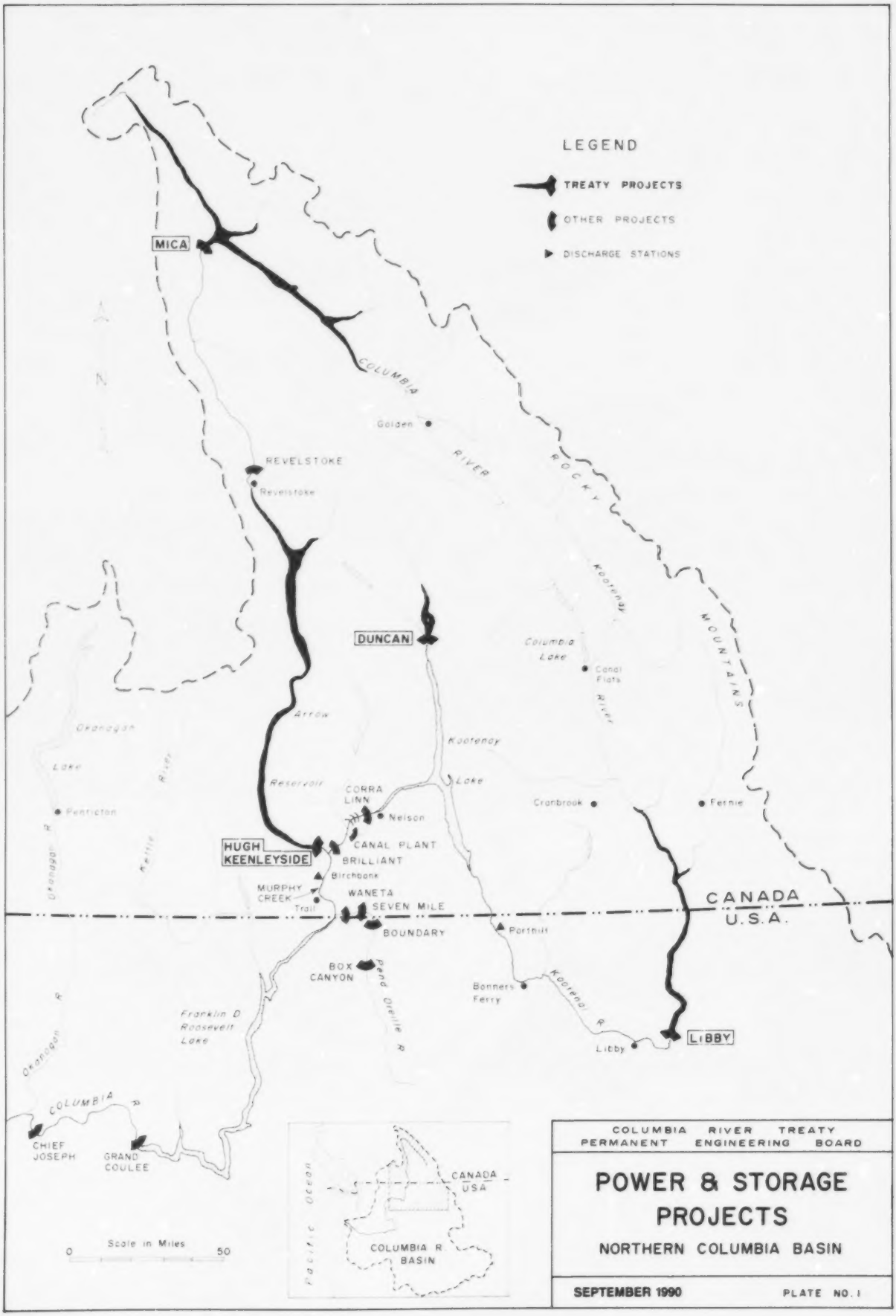

LEGEND
TREATY PROJECTS
OTHER PROJECTS
DISCHARGE STATIONS
MICA
COLUMBIA
Golden
RIVER
ROCKY
MOUNTAINS
REVELSTOKE
Revelstoke
DUNCAN
Columbia Lake
Canal Flats
Kootenay
River
Arrow
Lakes
Reservoir
Okanagan
Lake
River
Penticton
Okanagan R.
Kettle
CORRA LINN
Nelson
Kootenay
Lake
Cranbrook
Fernie
HUGH KEENLEYSIDE
CANAL PLANT
BRILLIANT
Birchbank
MURPHY CREEK
Trail
WANETA
SEVEN MILE
BOUNDARY
CANADA
U.S.A.
Porthill
BOX CANYON
Pend Oreille
Bonners Ferry
Kootenai R.
Franklin D Roosevelt Lake
Okanogan R.
LIBBY
Libby
COLUMBIA
CHIEF JOSEPH
GRAND COULEE
Scale in Miles
0
50
Pacific Ocean
CANADA
USA
COLUMBIA R. BASIN
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
POWER & STORAGE PROJECTS
NORTHERN COLUMBIA BASIN
SEPTEMBER 1990
PLATE NO. 1

TABLE 1

DUNCAN PROJECT

Duncan Dam and Duncan Lake

Storage Project	
Construction began	17 September 1964
Storage became fully operational	31 July 1967
Reservoir	
Normal Full Pool Elevation	1,892 feet
Normal Minimum Pool Elevation	1,794.2 feet
Surface Area at Full Pool	18,000 acres
Total Storage Capacity	1,432,400 ac-ft
Usable Storage Capacity	1,400,000 ac-ft
Treaty Storage Commitment	1,400,000 ac-ft
Dam, Earthfill	
Crest Elevation	1,907 feet
Length	2,600 feet
Approximate height above riverbed	130 feet
Spillway — Maximum Capacity	47,700 cfs
Discharge Tunnels — Maximum Capacity	20,000 cfs
Power Facilities	
None	

TABLE 2

ARROW PROJECT

Hugh Keenleyside Dam and Arrow Lakes

Storage Project	
Construction began	March 1965
Storage became fully operational	10 October 1968
Reservoir	
Normal Full Pool Elevation	1,444 feet
Normal Minimum Pool Elevation	1,377.9 feet
Surface Area at Full Pool	130,000 acres
Total Storage Capacity	8,337,000 ac-ft
Usable Storage Capacity	7,100,000 ac-ft
Treaty Storage Commitment	7,100,000 ac-ft
Dam, Concrete Gravity and Earthfill	
Crest Elevation	1,459 feet
Length	2,850 feet
Approximate height above riverbed	170 feet
Spillway — Maximum Capacity	240,000 cfs
Low Level Outlets — Maximum Capacity	132,000 cfs
Power Facilities	
None	

TABLE 3

MICA PROJECT

Mica Dam and Kinbasket Lake

Storage Project	
Construction began	September 1965
Storage became fully operational	29 March 1973
Reservoir	
Normal Full Pool Elevation	2,475 feet
Normal Minimum Pool Elevation	2,320 feet
Surface Area at Full Pool	106,000 acres
Total Storage Capacity	20,000,000 ac-ft
Usable Storage Capacity	
Total	12,000,000 ac-ft
Commitment to Treaty	7,000,000 ac-ft
Dam, Earthfill	
Crest Elevation	2,500 feet
Length	2,600 feet
Approximate height above foundation	800 feet
Spillway — Maximum Capacity	150,000 cfs
Outlet Works — Maximum Capacity	37,400 cfs
Power Facilities	
Designed ultimate installation	
6 units at 434 mw	2,604 mw
Power commercially available	December 1976
Presently installed	
4 units at 434 mw	1,736 mw
Head at full pool	600 feet
Maximum Turbine Discharge	
of 4 units at full pool	38,140 cfs

TABLE 4

LIBBY PROJECT

Libby Dam and Lake Koocanusa

Storage Project	
Construction began	June 1966
Storage became fully operational	17 April 1973
Reservoir	
Normal Full Pool Elevation	2,459 feet
Normal Minimum Pool Elevation	2,287 feet
Surface Area at Full Pool	46,500 acres
Total Storage Capacity	5,869,000 ac-ft
Usable Storage Capacity	4,980,000 ac-ft
Dam, Concrete Gravity	
Deck Elevation	2,472 feet
Length	3,055 feet
Approximate height above riverbed	370 feet
Spillway — Maximum Capacity	145,000 cfs
Low Level Outlets — Maximum Capacity	61,000 cfs
Power Facilities	
Designed ultimate installation	
8 units at 105 mw	840 mw
Power commercially available	24 August 1975
Presently installed	
5 units at 105 mw	525 mw
Head at full pool	352 feet
Maximum Turbine Discharge	
of 5 units at full pool	26,500 cfs